Nuclear Data in Radiation Therapy and Cancer Prevention

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The nuclear sciences and technologies continue to exert a major impact on health and medicine, both directly in terms of developing new modalities and treatments, and indirectly in terms of showing the advantages of improved approaches, leading the way for improved standards of care with conventional modalities. Most notable in therapy has been the successful application of beams of nuclear particles to radiation therapy, which demonstrated that precise dose localization could produce major improvements in disease control with reduced negative consequences. Throughout the world energetic protons, heavier ions, and neutrons are being used to treat cancers and other diseases, and new clinical facilities are being built. The design and construction of these machines as well as their clinical application require precise nuclear data. Successful localization of beams to complex treatment volumes for therapy demands detailed imaging of the anatomical structures and tissues as well as their cellular and subcellular characteristics. The contributions to diagnostic medicine of improved imaging and tomography based upon nuclear technologies are generally well known; however, the more recent incorporation of such methods into routine therapy is perhaps less appreciated. The large amount of input data along with increasingly more complex delivery systems in radiation therapy in turn require more accurate, more complex, more sophisticated treatment planning. Today, real-time imaging, planning, and verification are being done during treatment. Although analytical approaches have dominated this area of medicine, Monte Carlo methods have always offered a potential advantage which has never been fully realized, at least until recently. With improved calculational abilities and more extensive and more accurate nuclear and atomic data, Monte Carlo treatment planning is a major research topic with commercial products beginning to move into the marketplace. In any case, accuracy and efficiency remain serious limitations, where any approach can be successful in the clinic only if the service can be performed at a cost that is consistent with limits set by Federal health care and major providers. (The failure to translate successes in research laboratories to the clinic is recognized as a serious national problem and is being addressed at every level).

As stated previously, many of the biomedical advances have arisen in diagnostic medicine and, therefore, have contributed toward improved public health and prevention at least as much as therapy. Perhaps one of the most interesting applications has occurred in risk assessments and disease prevention for astronauts. Personnel in space receive significant doses from radiations, and it is considered one of the major biomedical hazards of long-term missions. Initially we possessed neither sufficient biological information nor cross-sectional data of sufficient accuracy to adequately estimate the risks. The new NASA Space Radiation Laboratory at Brookhaven has recently been commissioned, ushering in a new era of biomedical research in this field. The scientific issues, the research, and the history leading to this new facility exemplifies the potential success of collaborative ventures on the part of scientists and administrators from diverse fields, with physical and biological dosimetry playing a major role. Finally, the role of the Radiation Effects Team of the National Space Biomedical Research Institute in not only using physical and biodosimetric means to evaluate the risks from Space radiations but also showing the feasibility of pharmaceutical countermeasures after exposures will be reviewed.

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